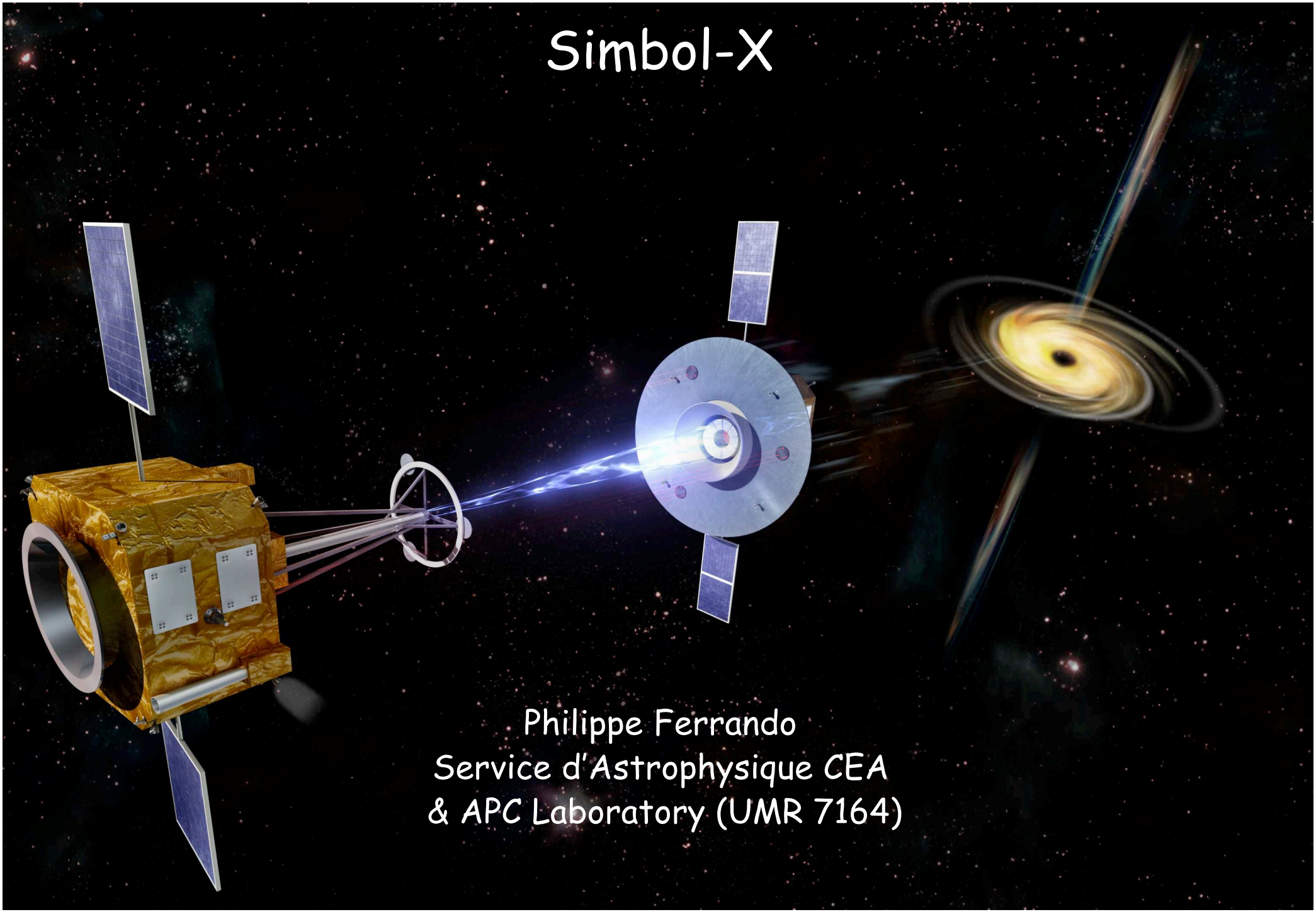
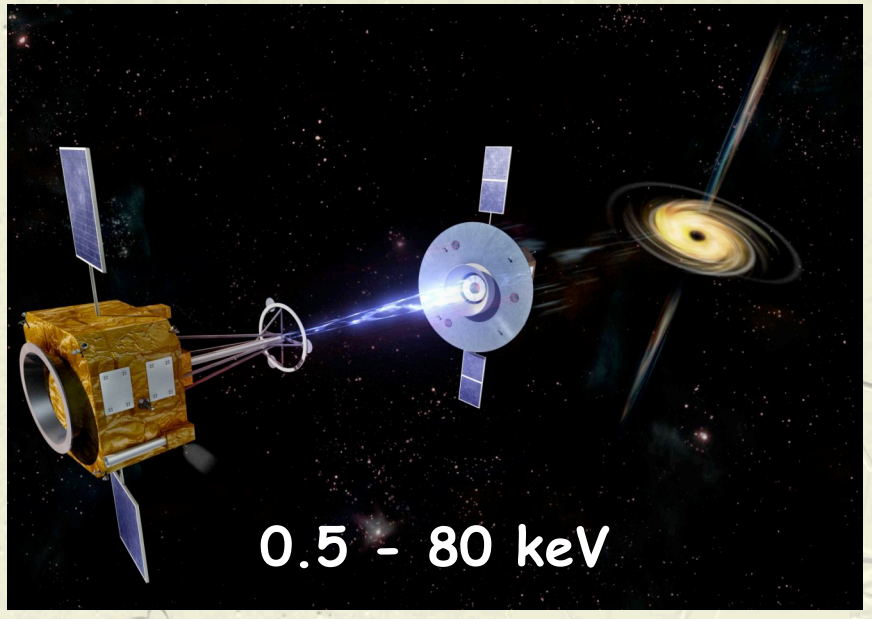
Simbol-X



Philippe Ferrando
Service d'Astrophysique CEA
& APC Laboratory (UMR 7164)

0.1–10 keV

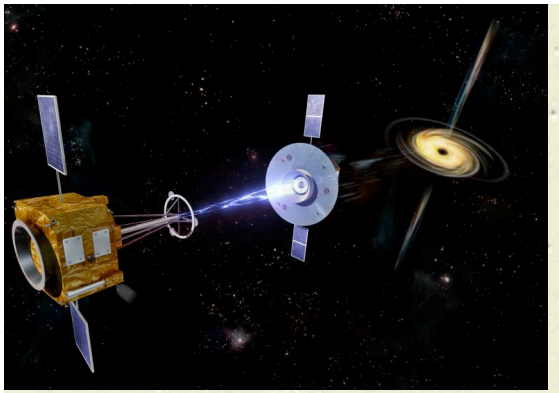


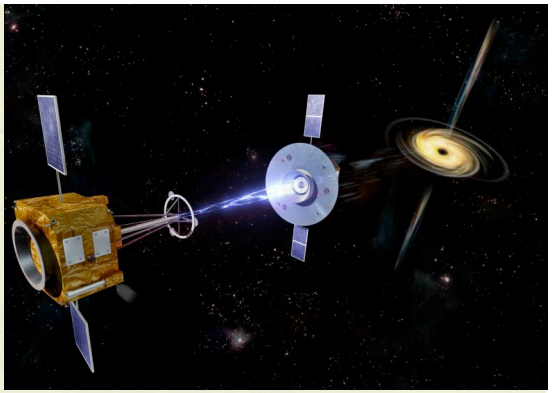
15 keV-10 MeV

Simbol-X

A high energy astrophysics observatory

Focusing hard X-rays thanks to the formation flight technology





International collaboration

Participating laboratories

F : CEA/Saclay, CESR/Toulouse, APC/Paris, LAOG/Grenoble, Obs.Paris/Meudon

It : (INAF :) O.A.Brera, Roma, Palermo, IASF Milano, Bologna

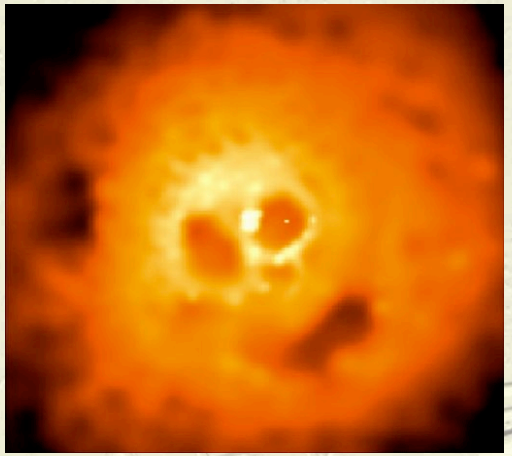
D : MPE Garching & I.A.A.Tübingen

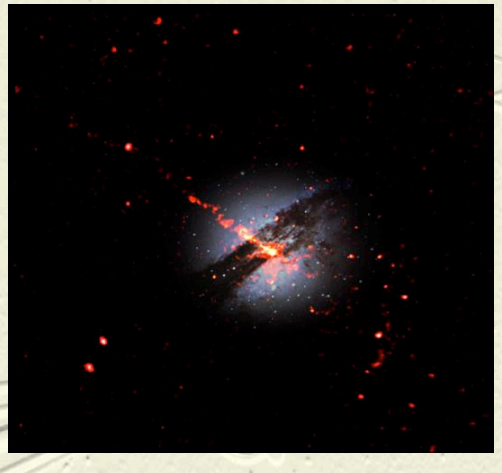
- Conceived as an observatory, opened (in part) to the whole astrophysics community

Simbol-X : observing the High Energy Universe

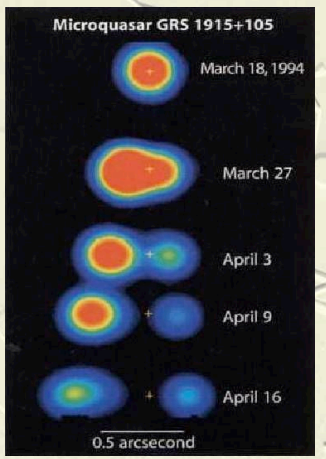
High energy phenomena are major actors of the dynamics of the Universe, via injection of matter and energy…

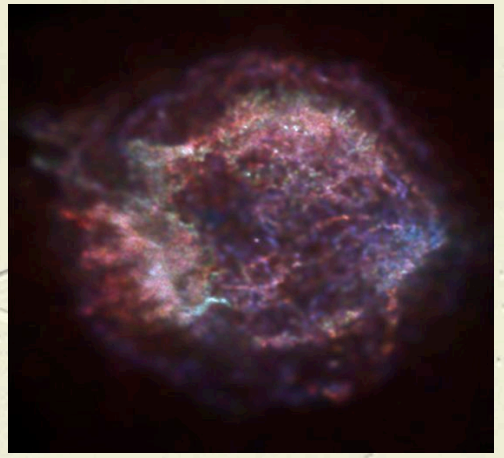
from extragalactic…





… to Galactic scales





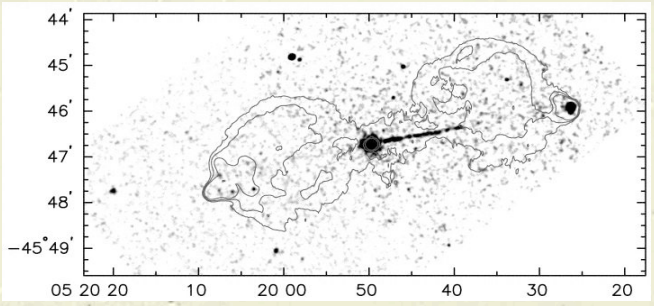
Scientific domain characterized by non-thermal emissions in X and γ rays, strongly variable for compact objects, often accompanied by thermal emission to disentangle

Main goals, questions, et targets

1. **Accretion : physics and census**

   Questions : matter under extreme gravity and B field conditions, compact objects parameters determination (BH spin, mass, NS magnetic field), accretion power in the Universe

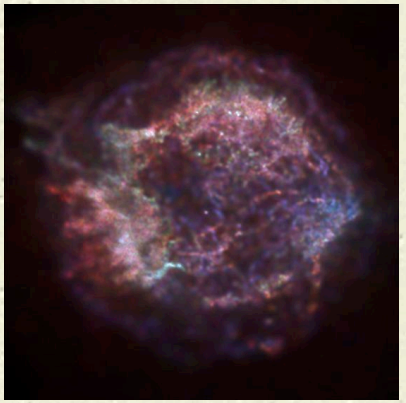
   Targets : X-ray binaries, Ultra-Luminous X-ray sources, Galactic Centre, Active Galactic Nuclei, X-Ray Cosmic Background

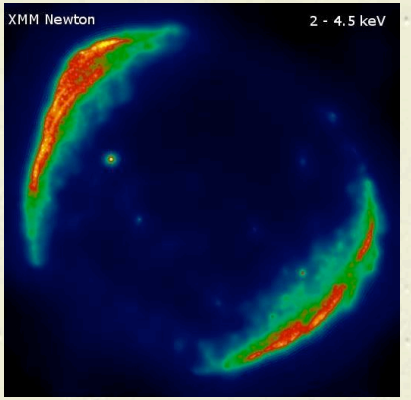


2. **Particle acceleration :**

   Question : acceleration processes limits, origin of cosmic rays

   Targets : SNRs, pulsars, jets (AGN, microquasars), galaxy clusters



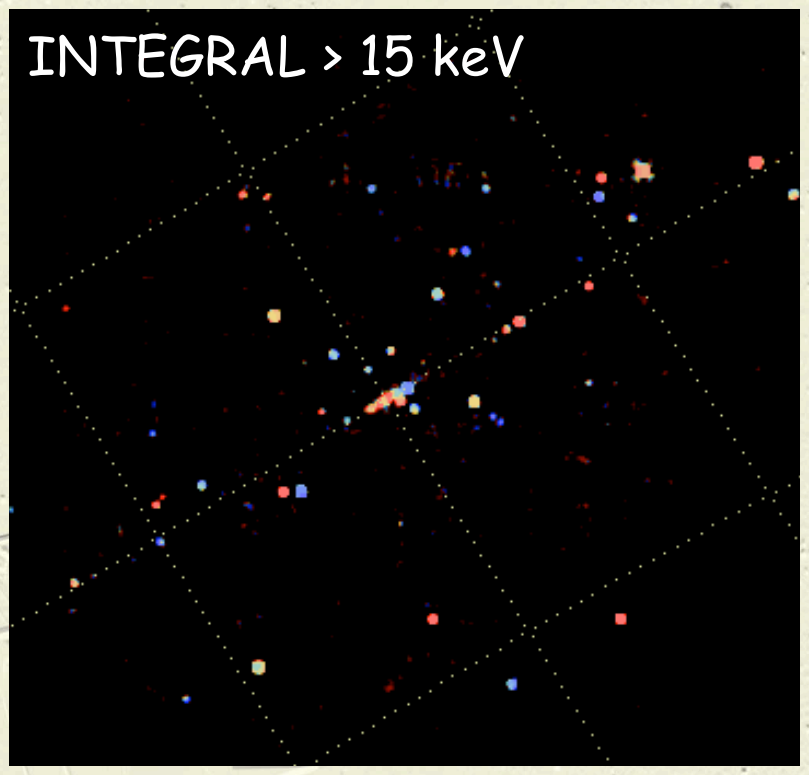


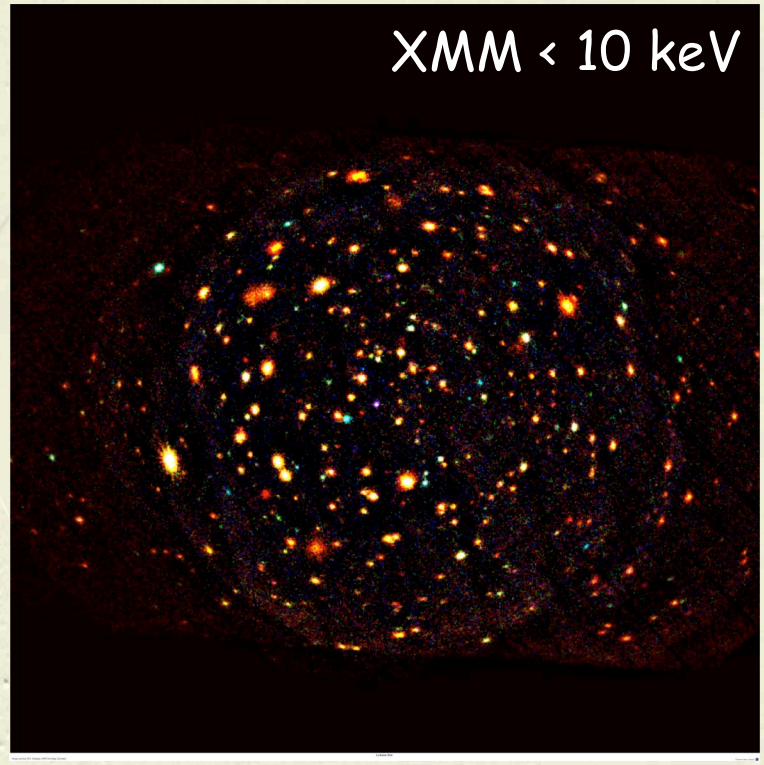
3. **Nucleosynthesis**

   Question : how do star explode ?

   Targets : young supernovae remnants

Hard and Soft X-ray astrophysics





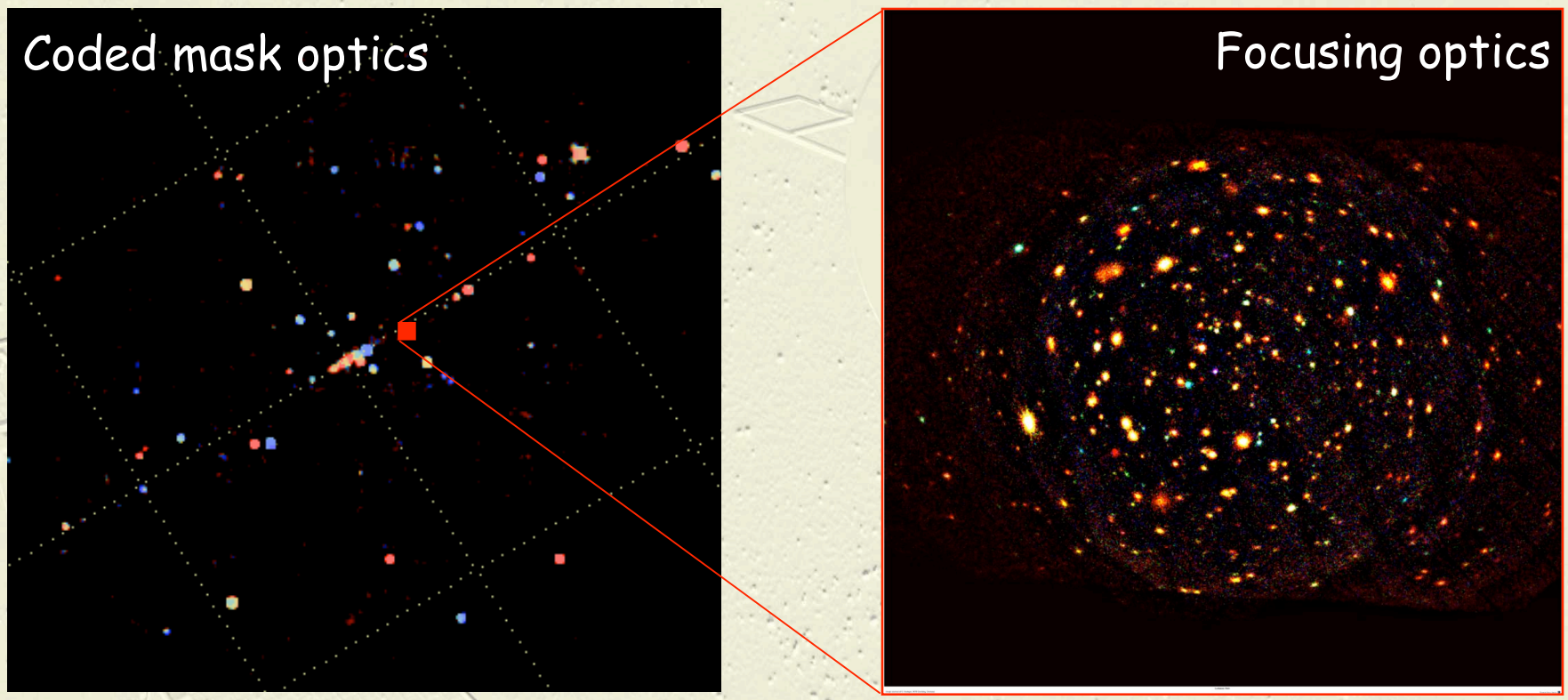
30 degrees

30 arcmin

Large field of view instruments have unveiled the richness of the domain, but limitation in sensitivity, angular resolution, integration times, prevent going further…

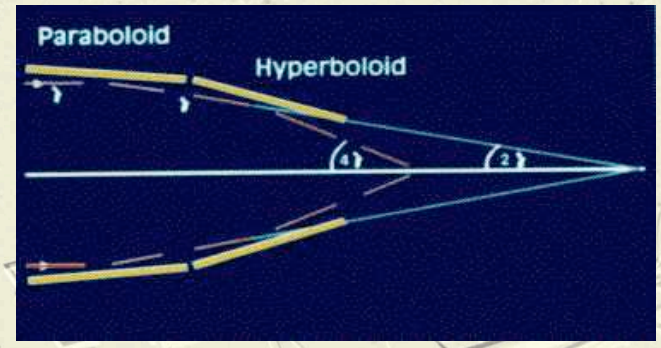
Simbol-X : go beyond exploratory phase

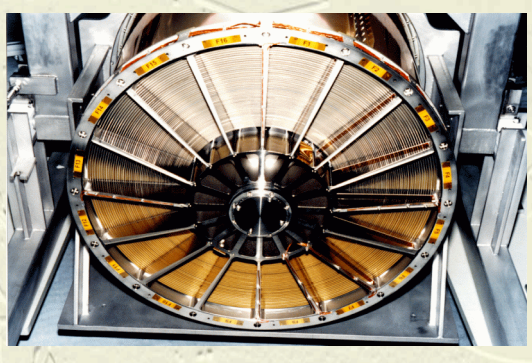
Have the XMM angular resolution and sensitivity in the INTEGRAL/ISGRI energy range

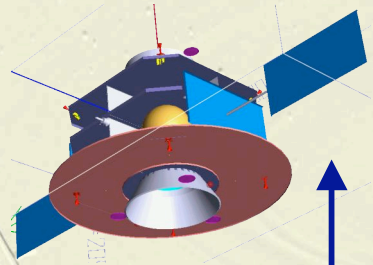


The only way to go : focusing

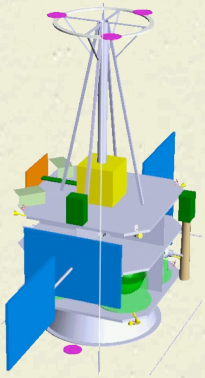
How ? Extend to the hard X-rays the successful "soft X-rays" technics, with very long focal length possible thanks to formation flight





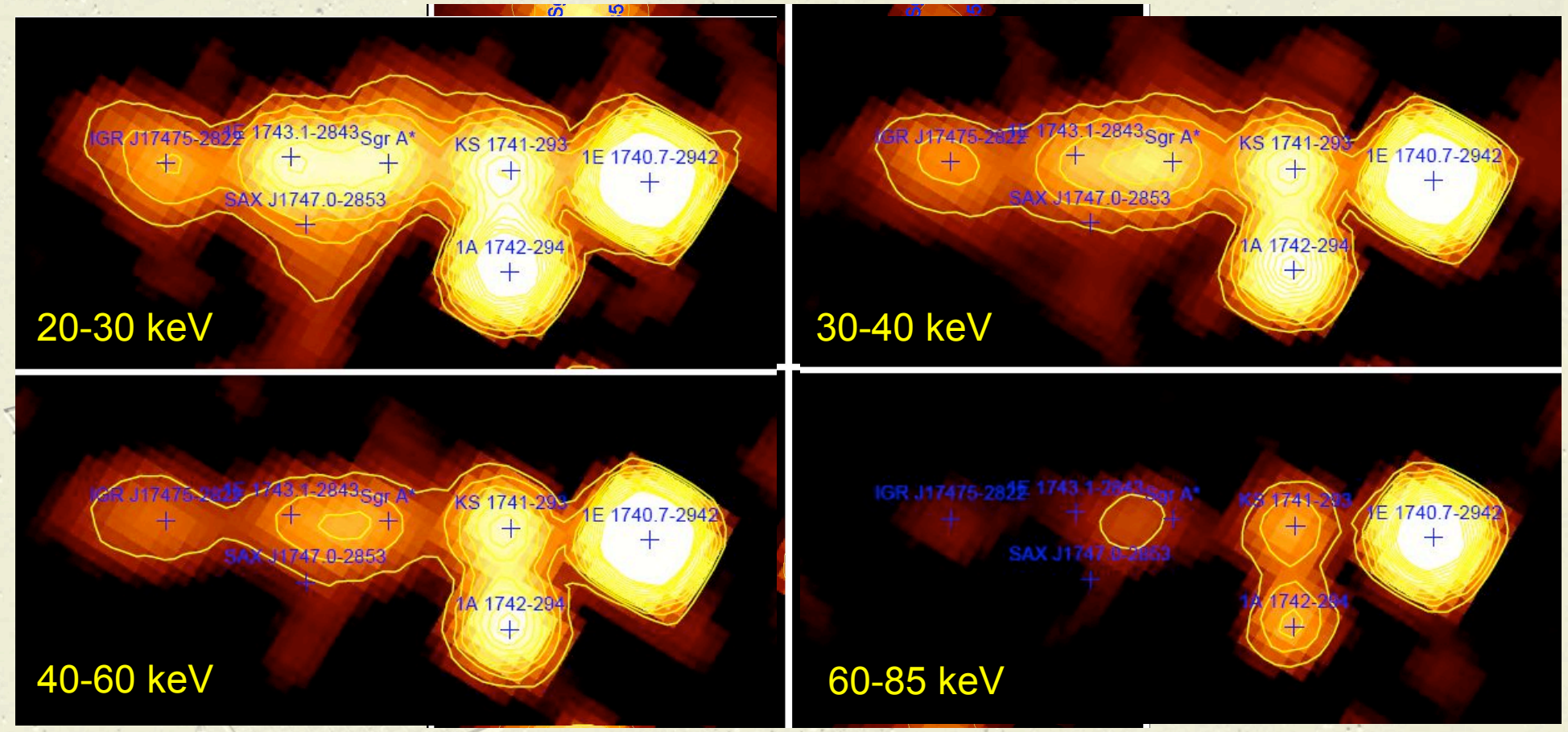


30 m



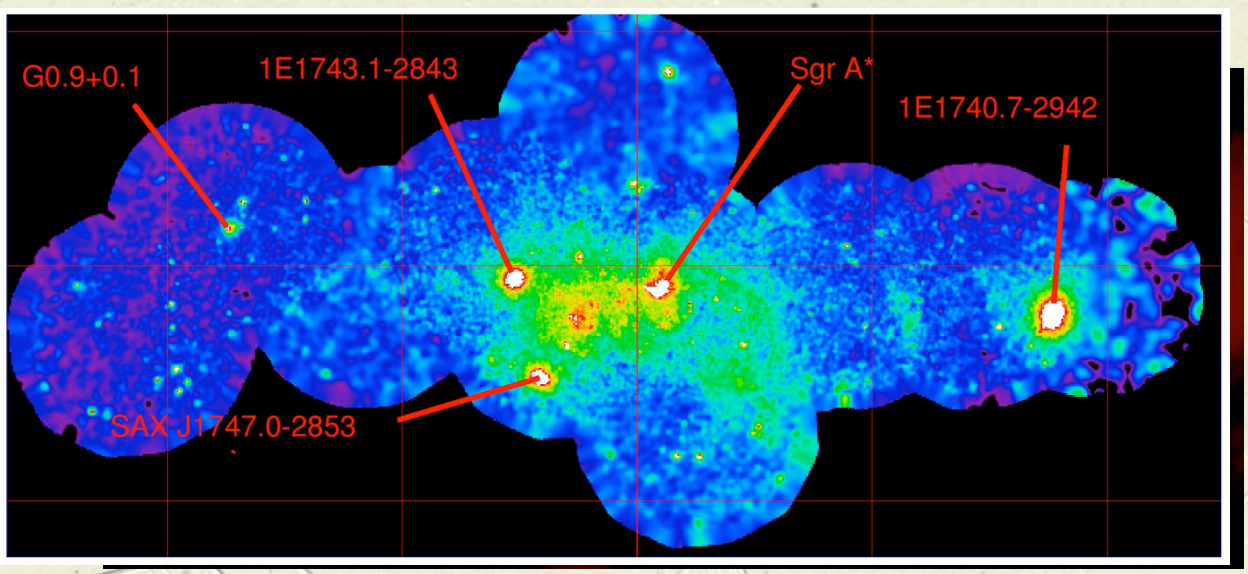
Grazing incidence : $E_{max} \propto 1/\theta \propto$ Focal Length

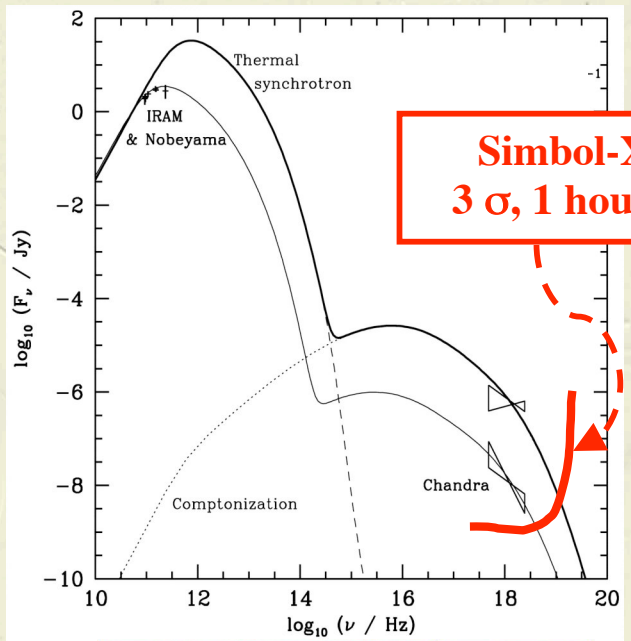
Accretion : solve the Galactic Centre enigma around SgrA*



An excess around the centre, but no identification of the origin…

The Galactic Centre with Simbol-X

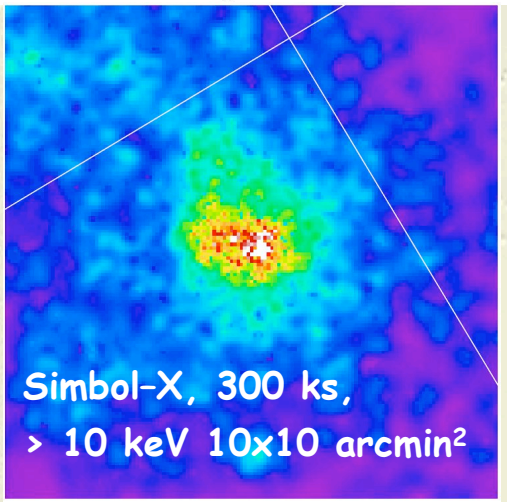




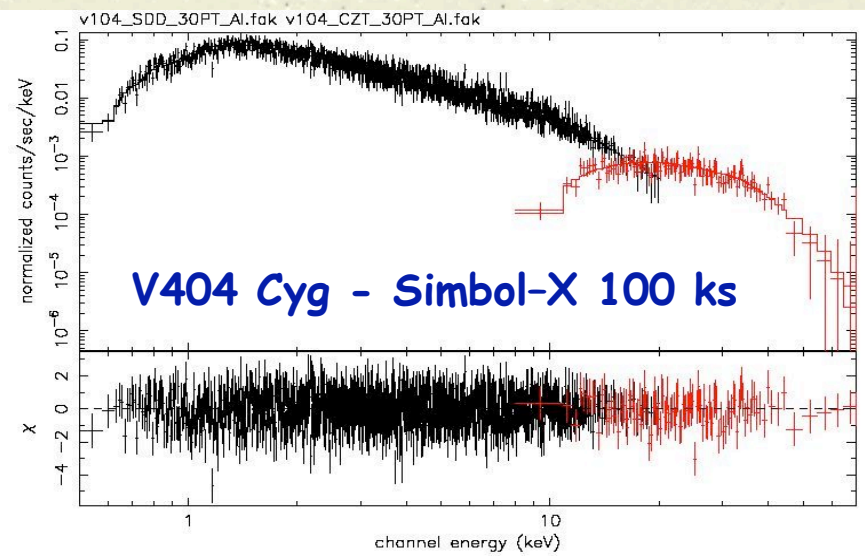
Angular resolution : localize the sources

Sensitivity : measure SgrA* spectrum

Spectro-imaging : solve the diffuse X-ray emission enigma

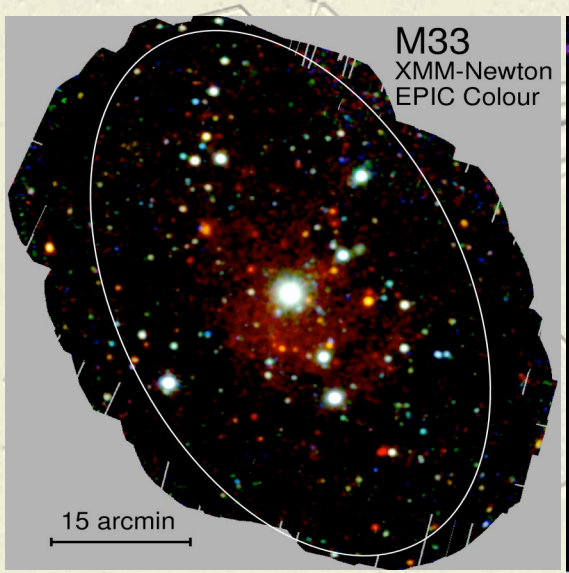


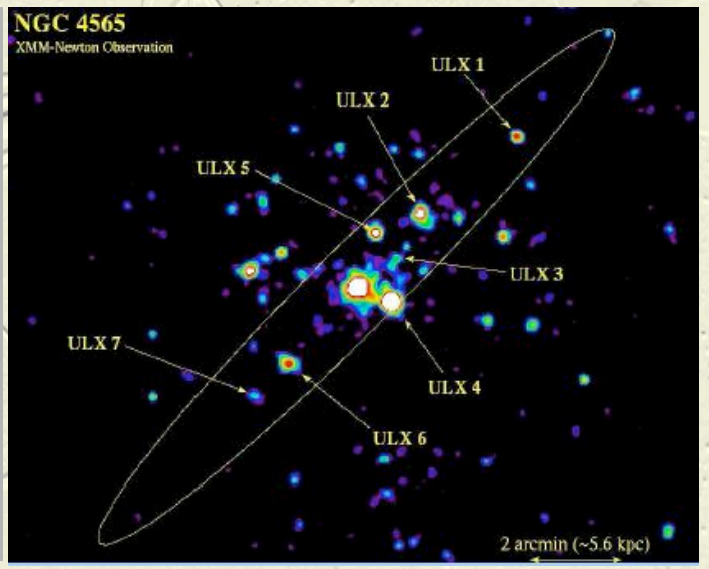
Accretion in binary systems



In Milky Way

access to quiescence state, and follow and characterize the change of state
(« ADAF » vs jets ? Difference between neutron stars and black holes ?)



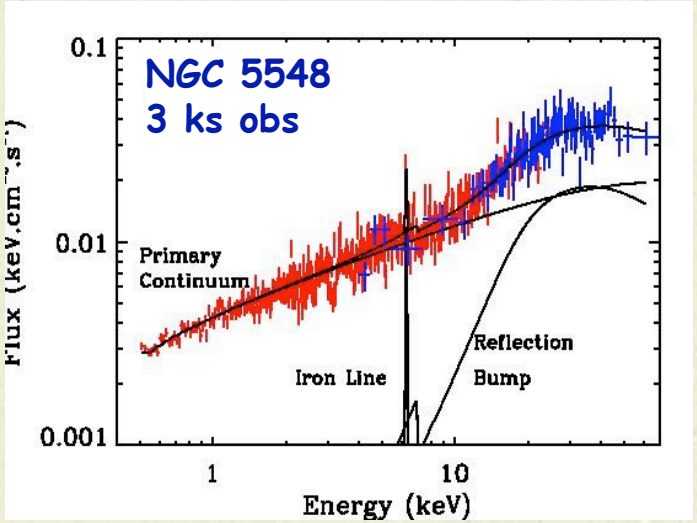


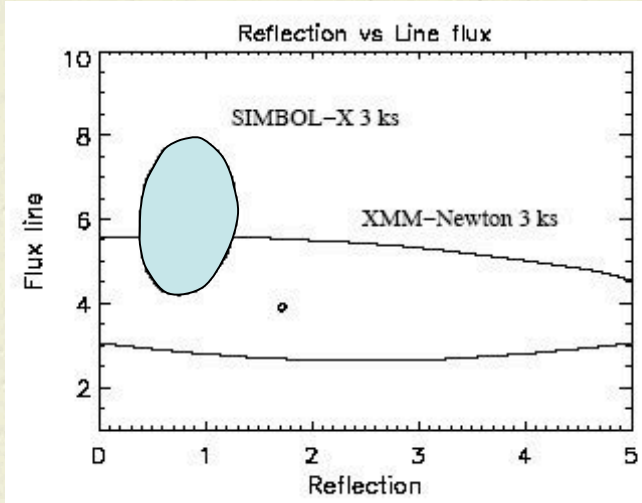
Black hole demography in outer Galaxies

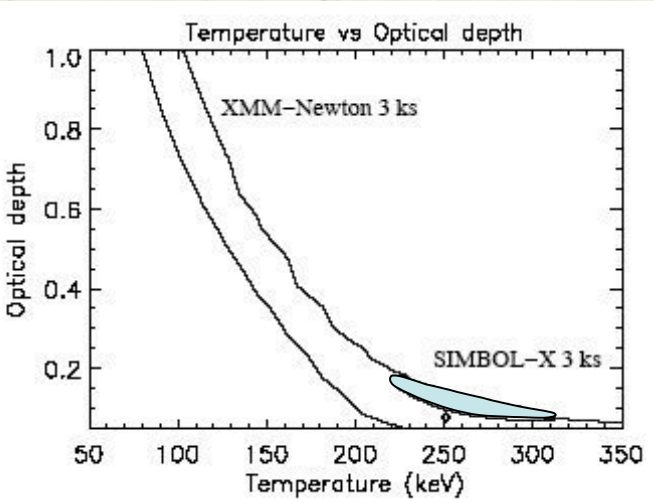
First hard X-rays mapping of binaries in local group

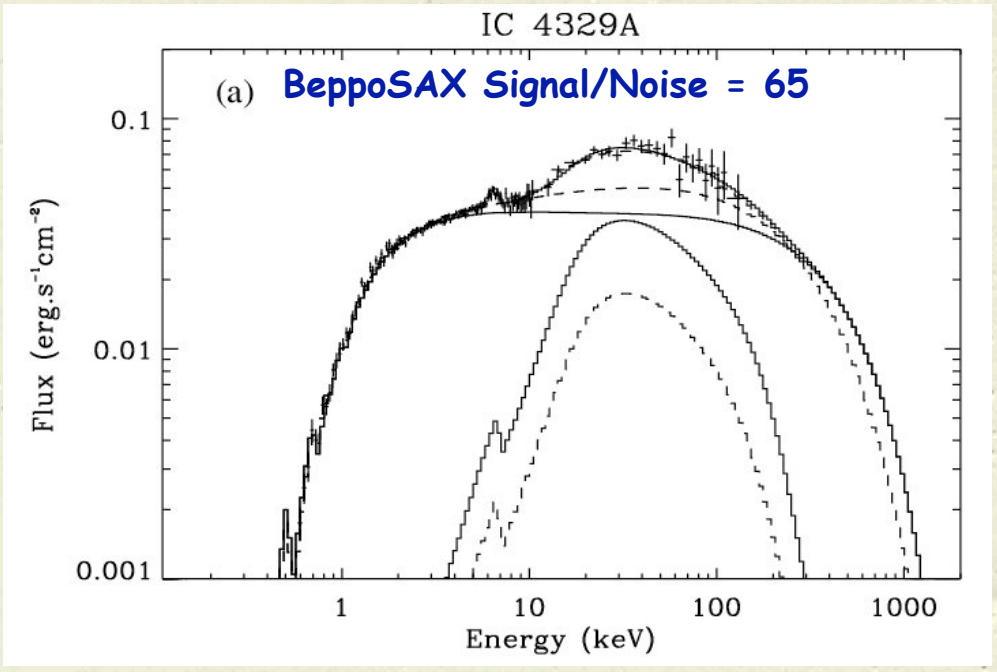
Caracterisation of ULX's, with potential mass determination via QPO's

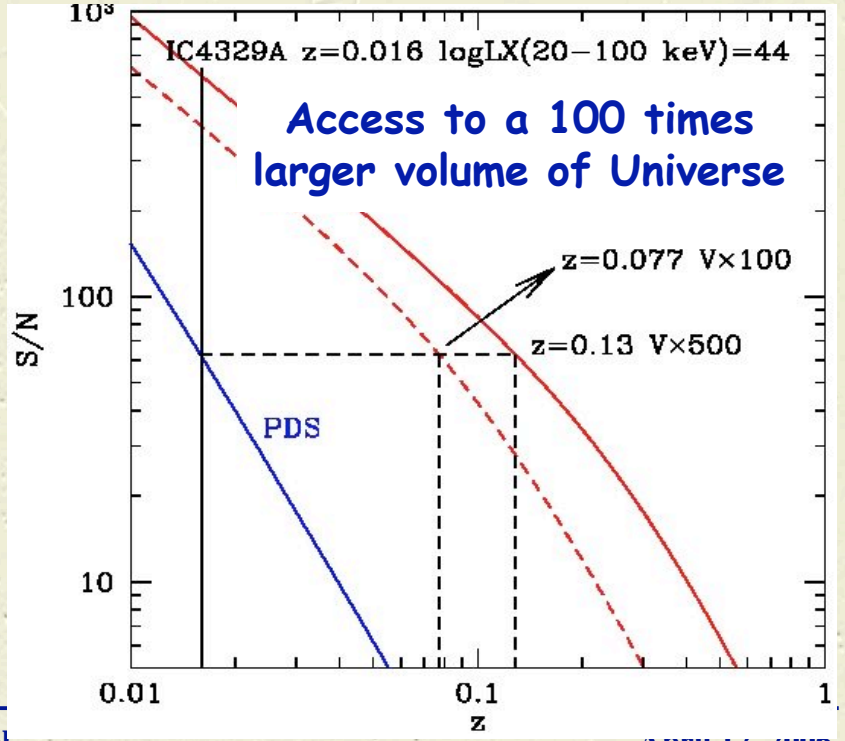
Accretion in SMBH : spectral variability & statistics



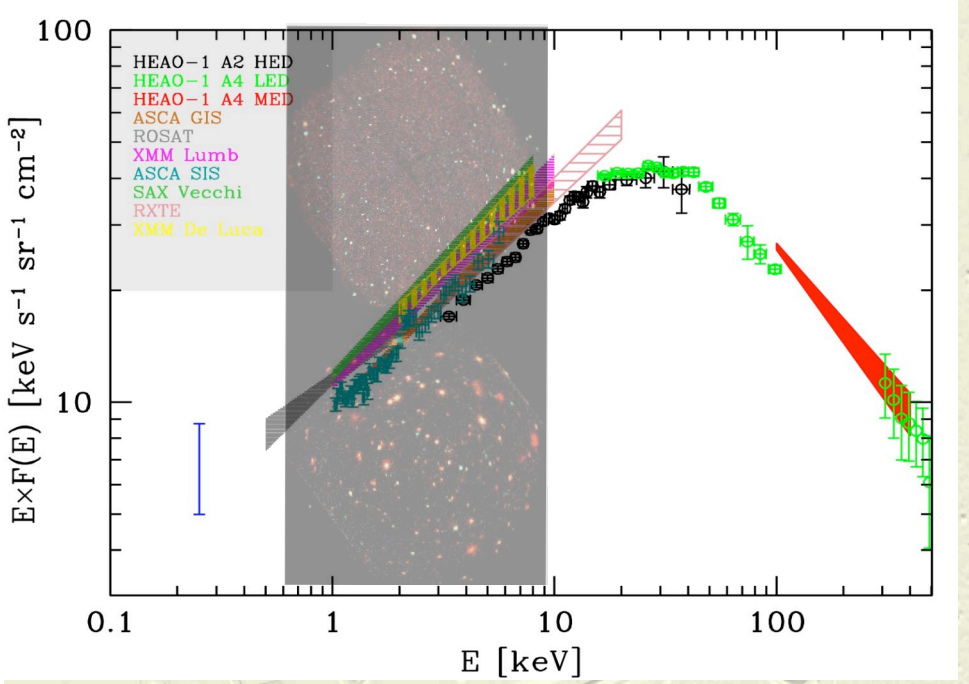




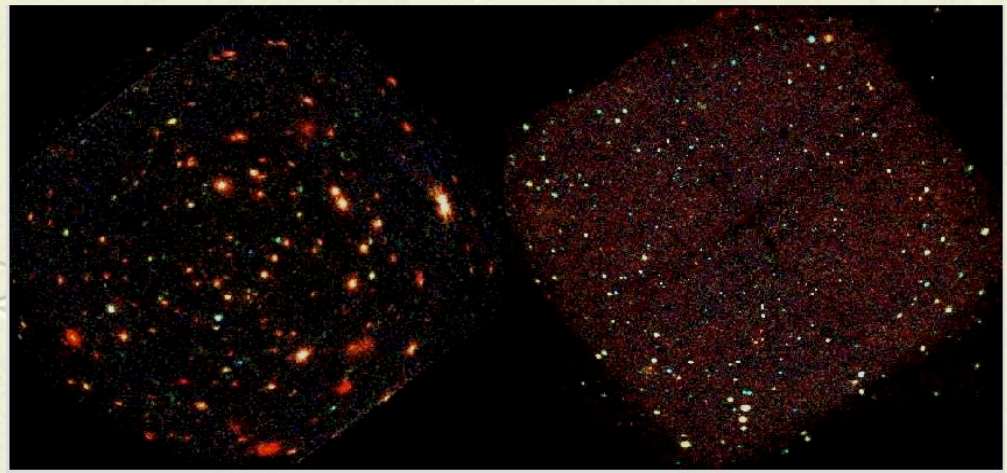




History of accretion : resolve the X-ray background



Record of Super Massive Black Holes history, with links to the stellar formation

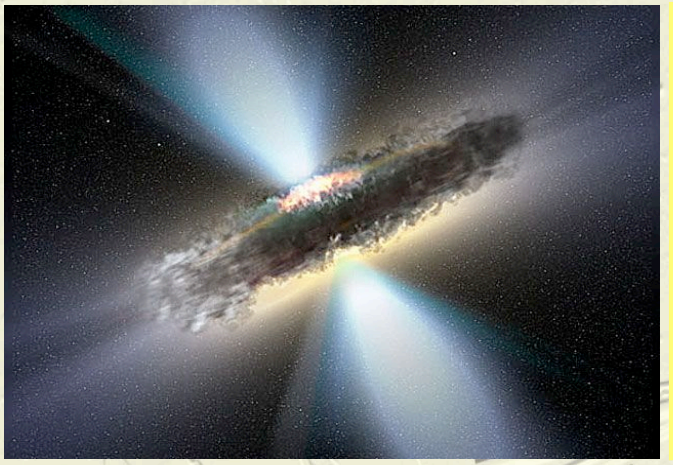


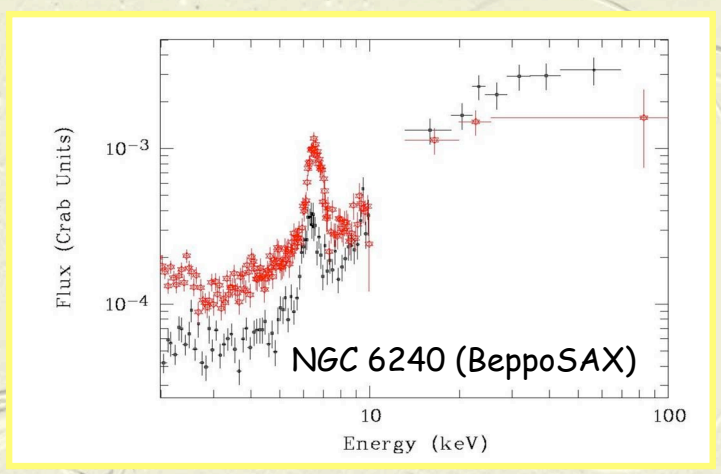
About 50 % resolved in sources in the 7–10 keV band

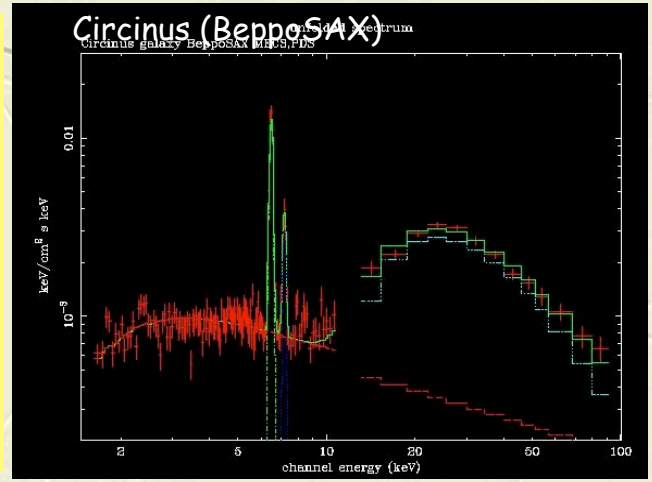
But less than a few % resolved beyond 10 keV, at the emission peak !

Simbol-X : find out the obscured active galaxies

CXRB models : major contribution from obscured AGNs, but parametres are not constrained (evolution, energy cut-off, absorption)



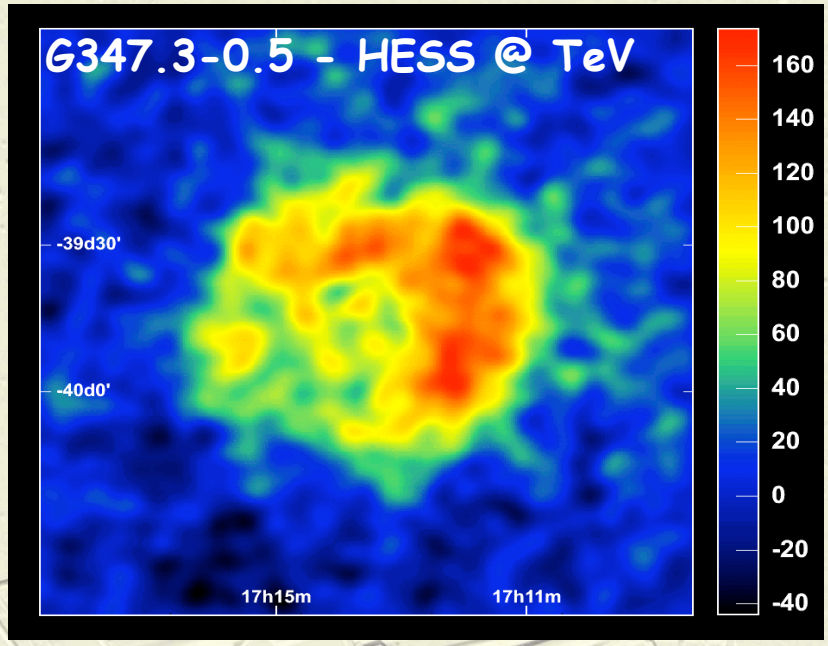


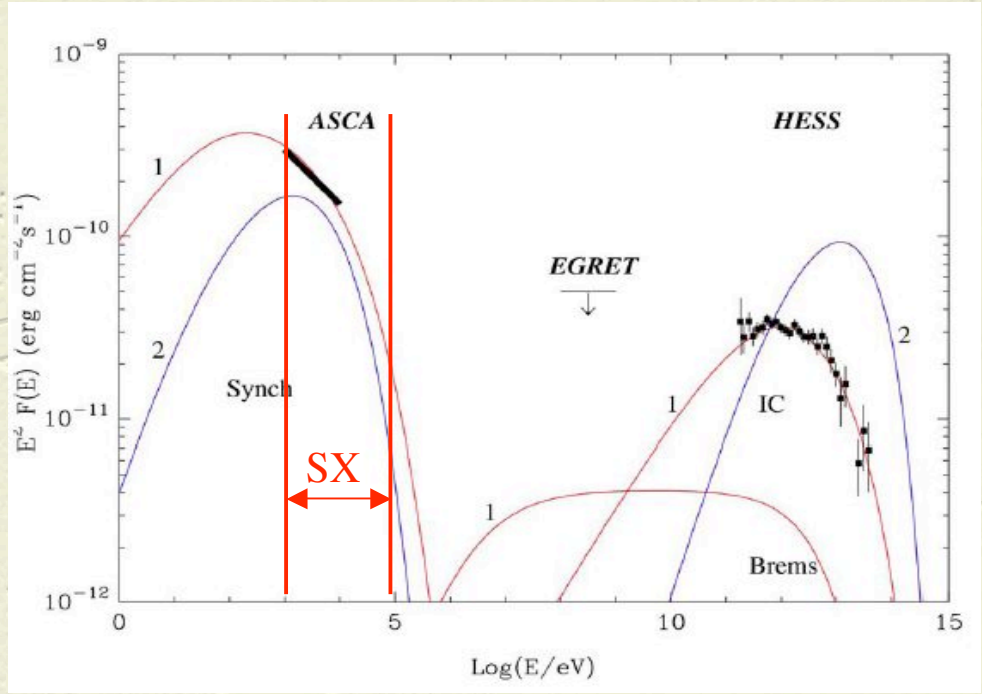


To break the degeneracy, we must find the sources

Simbol-X will resolve from 35 to 65 % of the CXRB in the [20-40] keV band (20 sources per 1 Ms pointing, for 12 arcmin FOV)

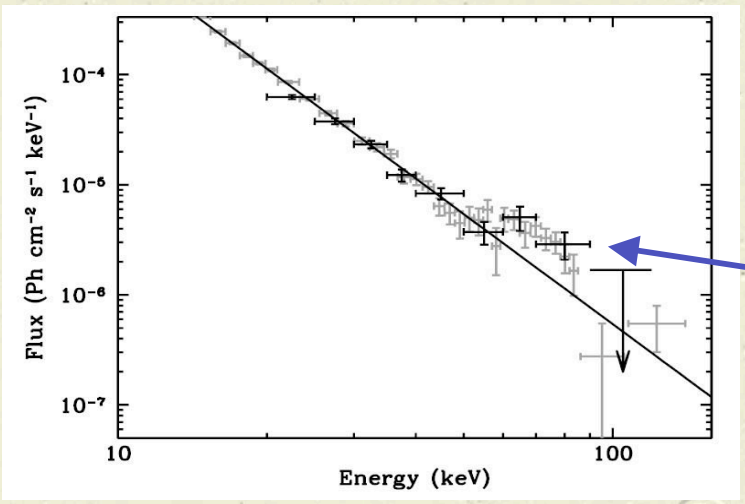
Acceleration : in SNRs shocks





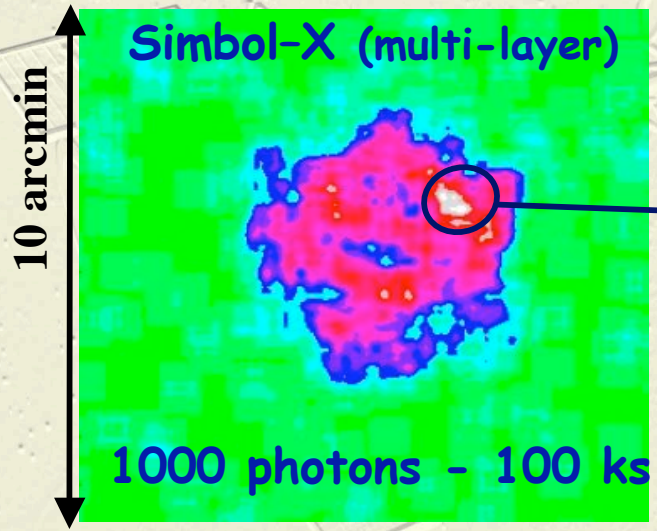
With Simbol-X : mapping of the synchrotron emission, determination of the maximum energy of the electrons, correlation with GeV and TeV emissions

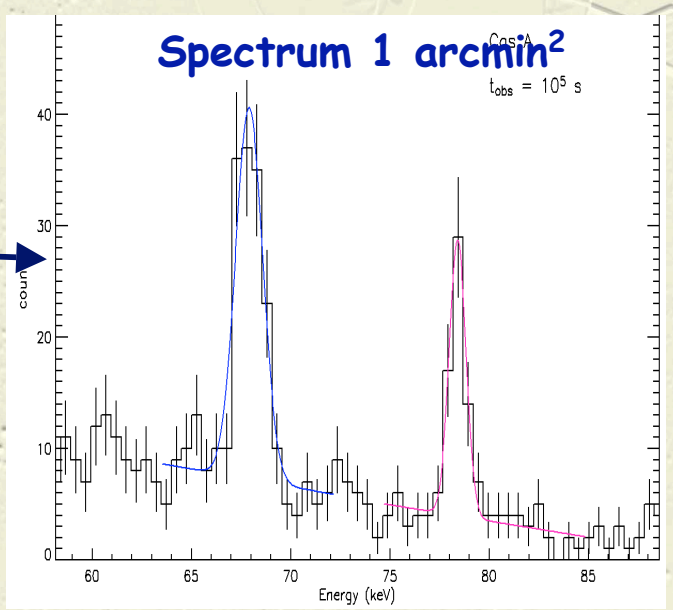
Nucleosynthesis : looking for ^{44}Ti emission



^{44}Ti : explosive nucleosynthesis product
Period of 88 years
Lines (^{44}Sc) at 68 and 78 keV

Detected only in CasA (so far), by BeppoSAX et INTEGRAL





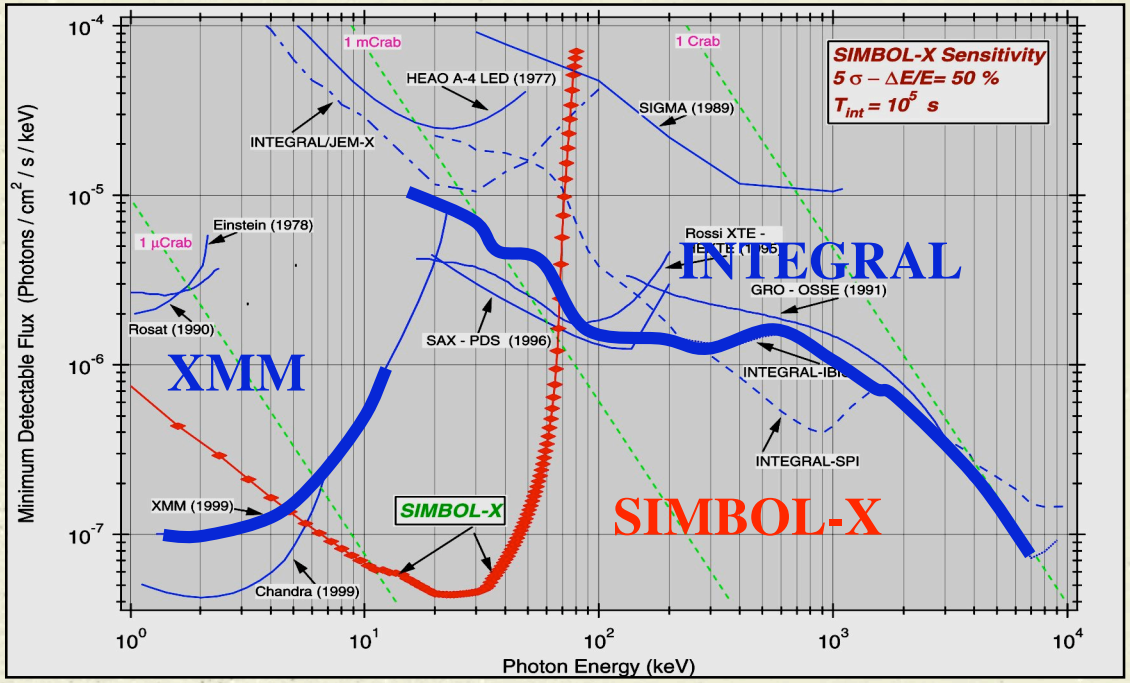
Science requirements

Emin < 1 keV
Emax > 50 keV, goal > 80 keV

ΔE : 150 eV @ 6 keV (Fe Kα)
1 keV @ 60 keV (^{44}Ti)

Δθ : < 30 arcsec, goal 15 arcsec
FOV : 6 arcmin, goal 12 arcmin

Δt : 1 ms, goal 50 microsecondes

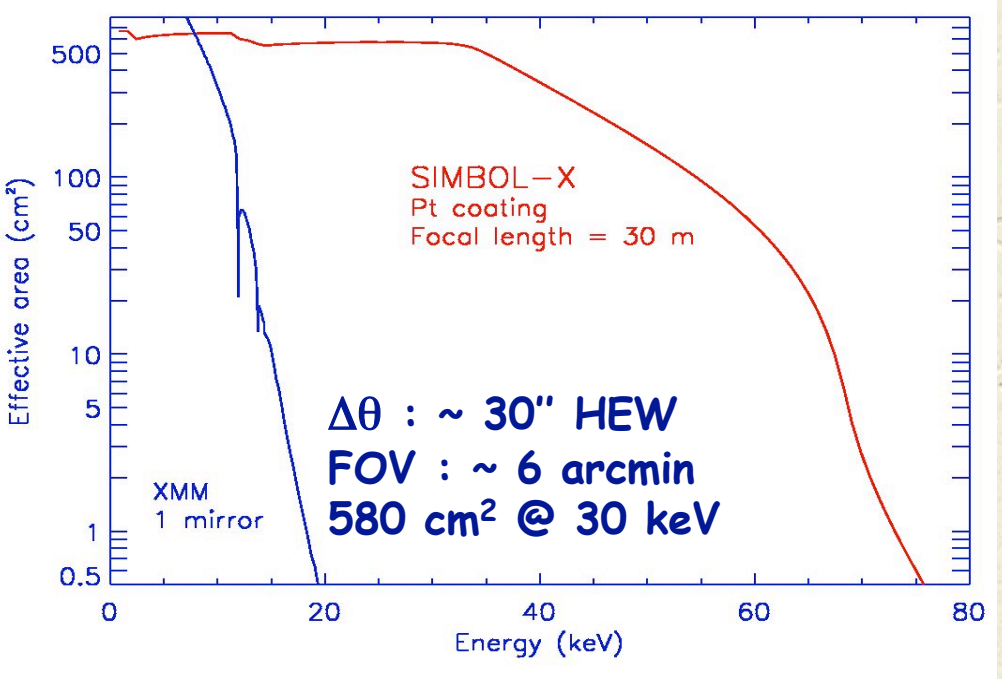


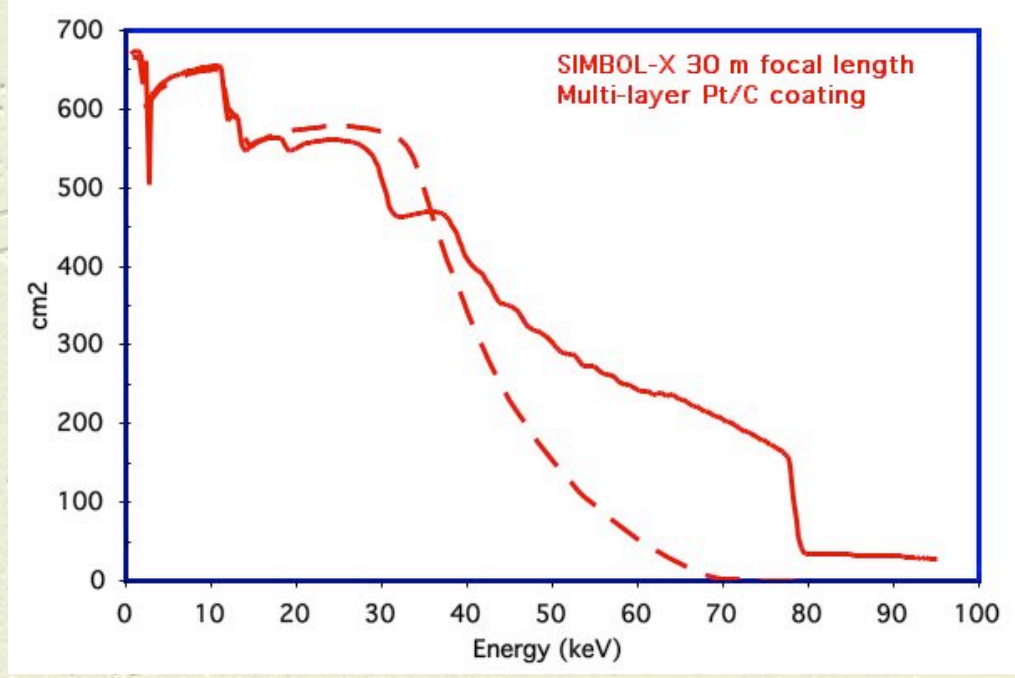
Sensitivity : 10^{-8} ph/cm²/s/keV for E < 40 keV goal 80 keV
10^{-14} erg/cm²/s [20-40 keV] (1 μCrab)

⇒ Large effective area, very low background, excellent angular resolution

Optics & coating

- Heritage from XMM-Newton : nickel shells obtained by electroforming replication method; low mass obtained via a reduced thickness of shells

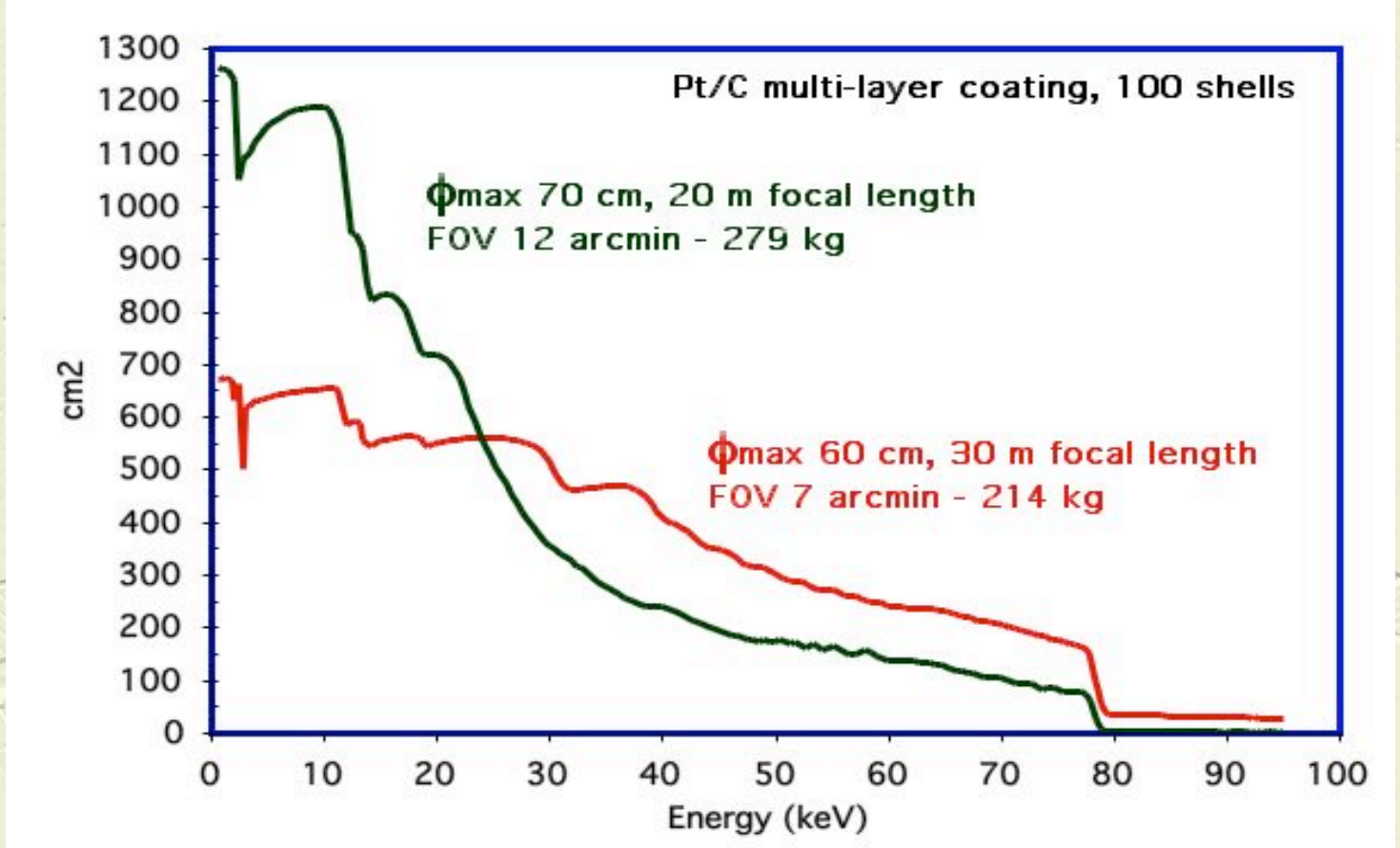




Shell diameters : 290 to 600 mm
Angles : 0.07° to 0.142°
Shell thickness : 0.12 to 0.30 mm
Number of shells : 100
Pt coating
Total mass : 213 kg

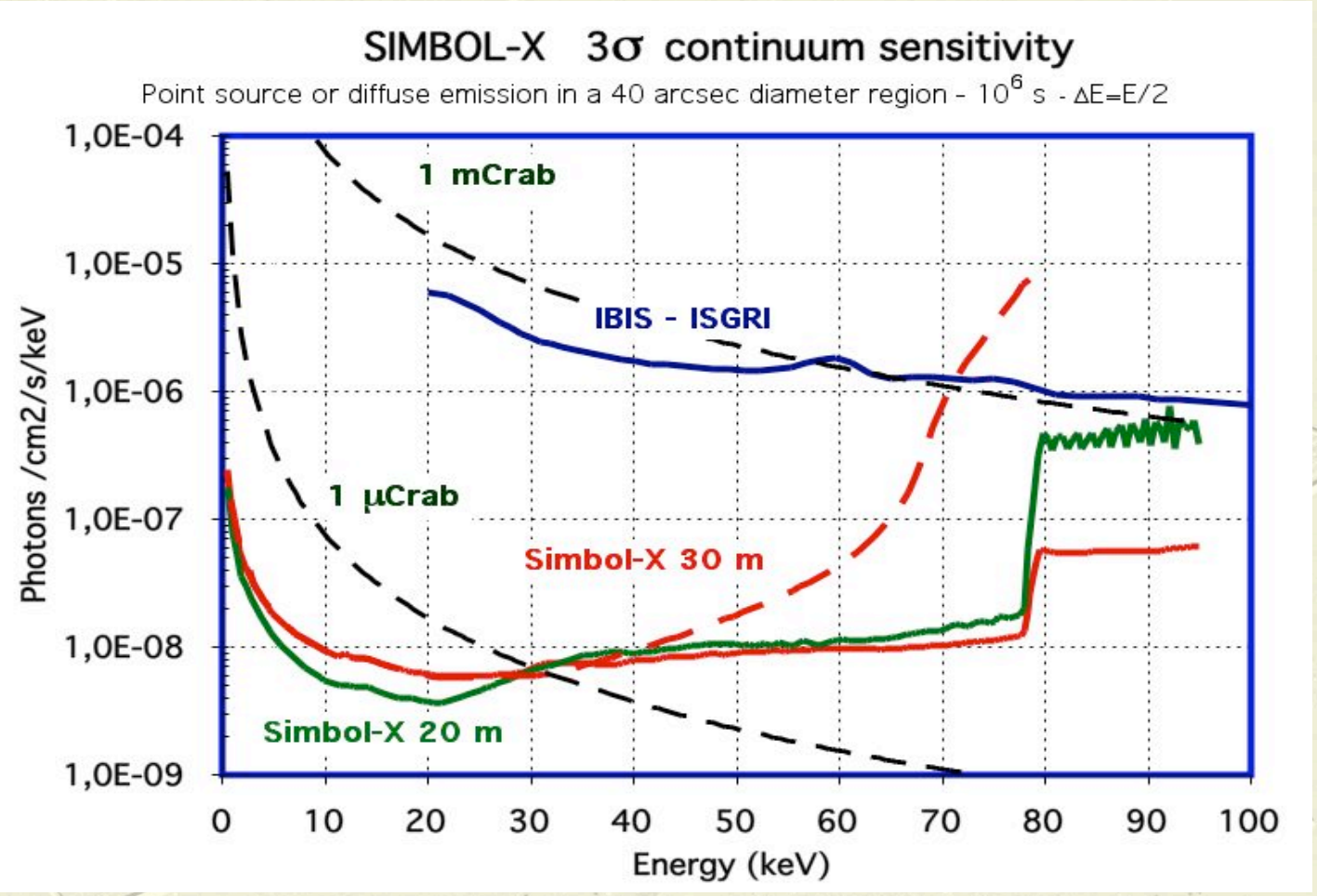
Same parameters except for coating,
Pt/C multi layer
Strong increase of response above 40 keV
Small increase of field of view : 7 arcmin

Optics, shorter focal length option

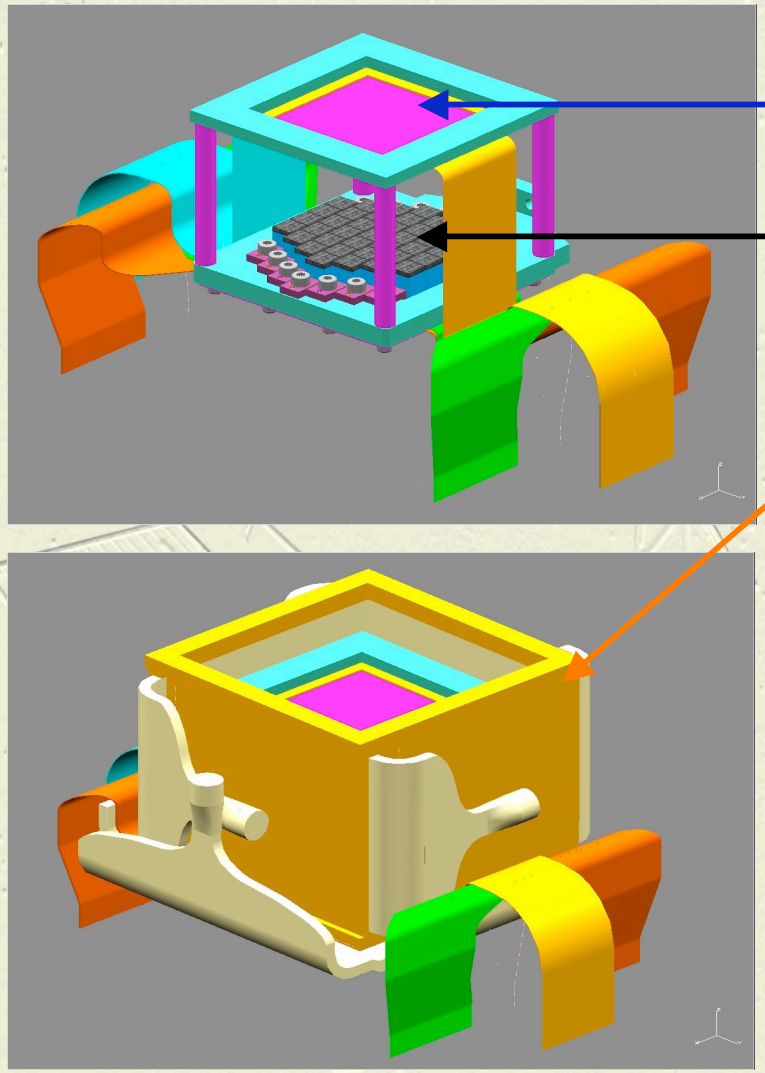


Strong increase of FOV and gain in plate scale, but less effective area above 25 keV

Phase A trade off with multi-layer possibility : maximise the field of view and/or the highest energy



The focal plane unit



Low energy detector (450 μm Silicon)

High energy detector (2 mm Cd(Zn)Te)

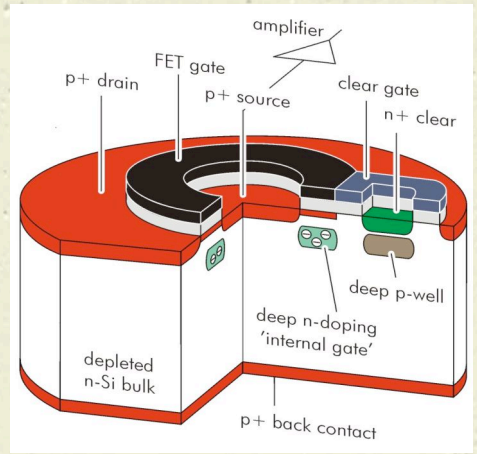
Active anticoincidence and passive shield

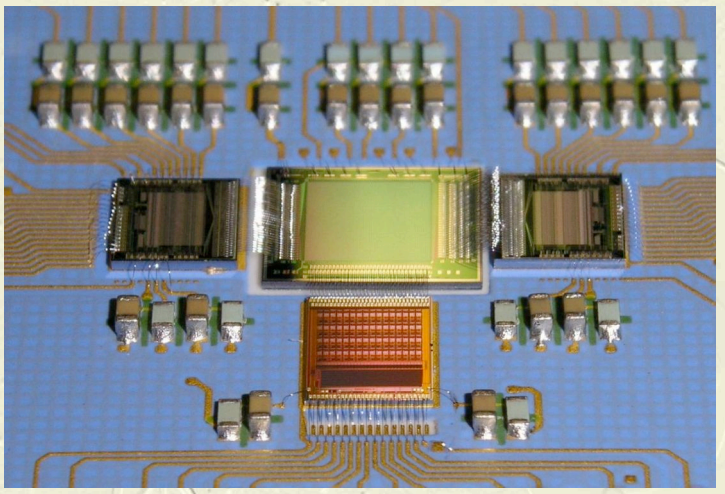
Basic starting parametres

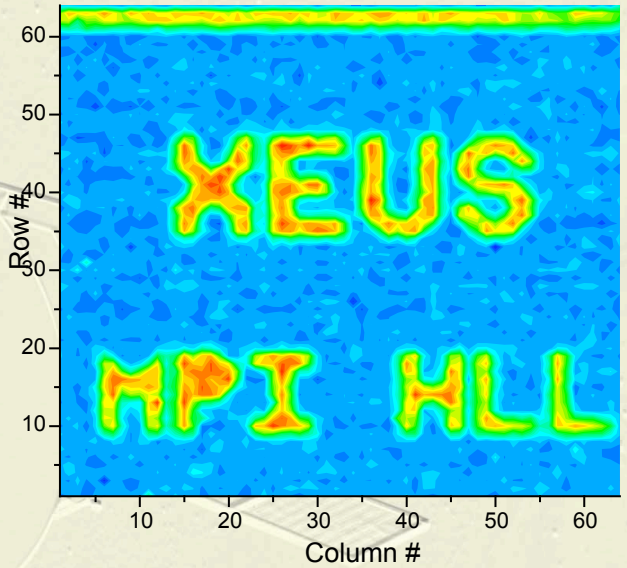
- Spectro-imaging system
- Pixel size ~ 500 μm (PSF oversampling)
- Full size : ~ 8×8 cm^2
- "Room temperature" operations
- Fast reading (used in anticoincidence)

Low energy detector

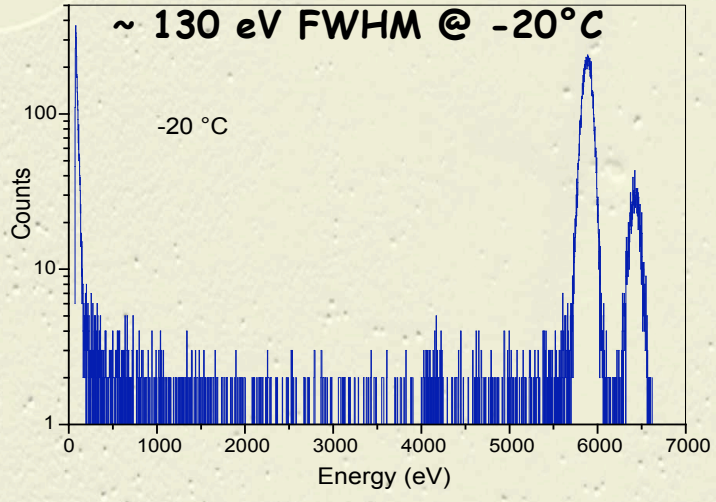
Macro Pixel Detector with integrated DEPFET





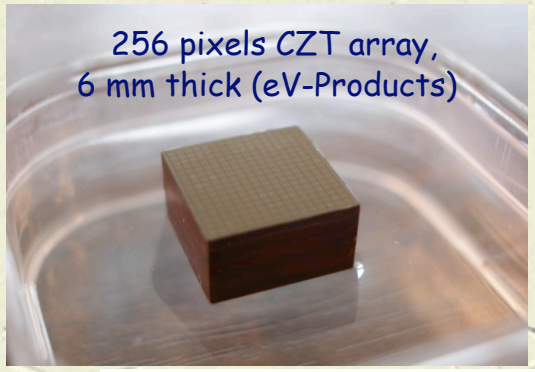


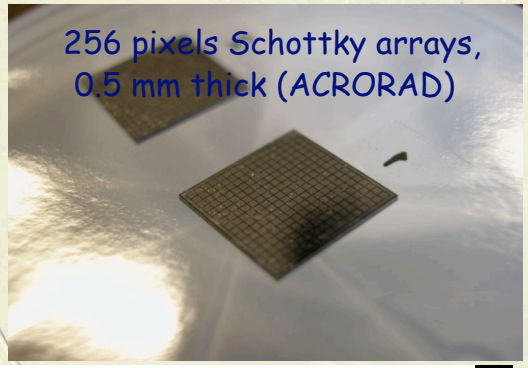
- Low power consumption
- Internal amplification
- Room temperature operations
- Active Pixel Sensor type
- 100 % filling factor
- Adjustable pixel size (50 μm to 1 mm)
- Fast, parallel readout possible



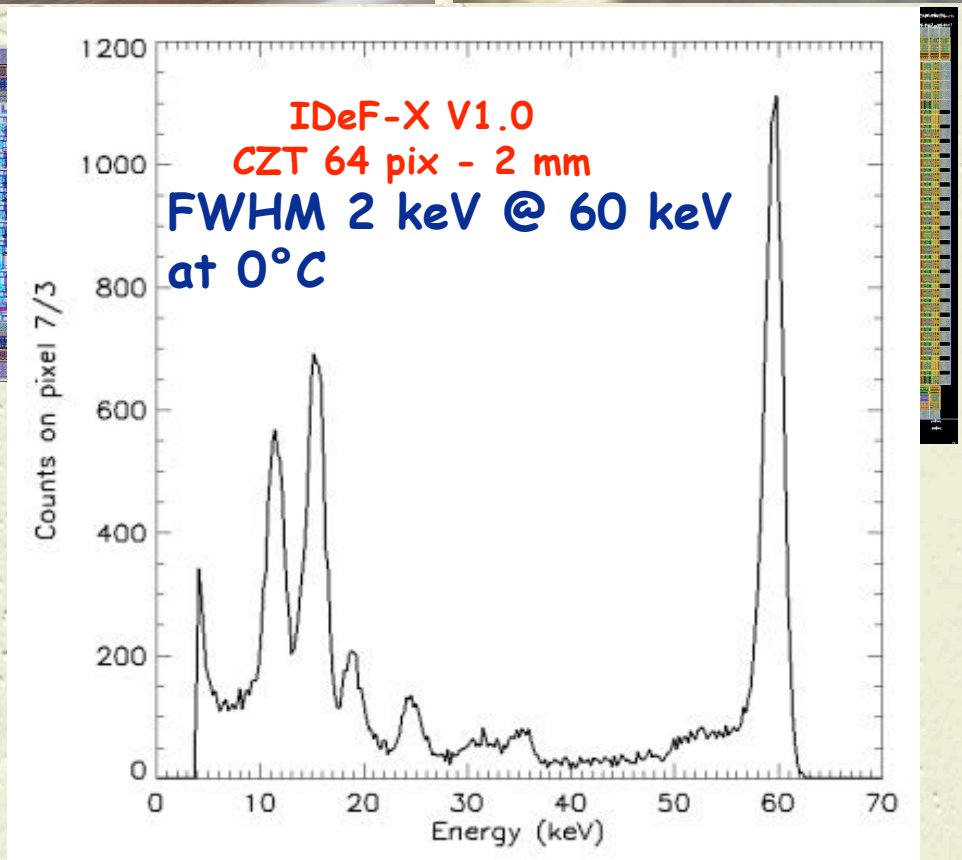
High Energy Detector : R&D CNES/CEA

- Tests of pixellated Cd(Zn)Te matrices

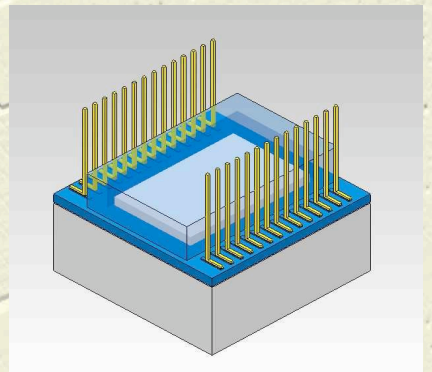




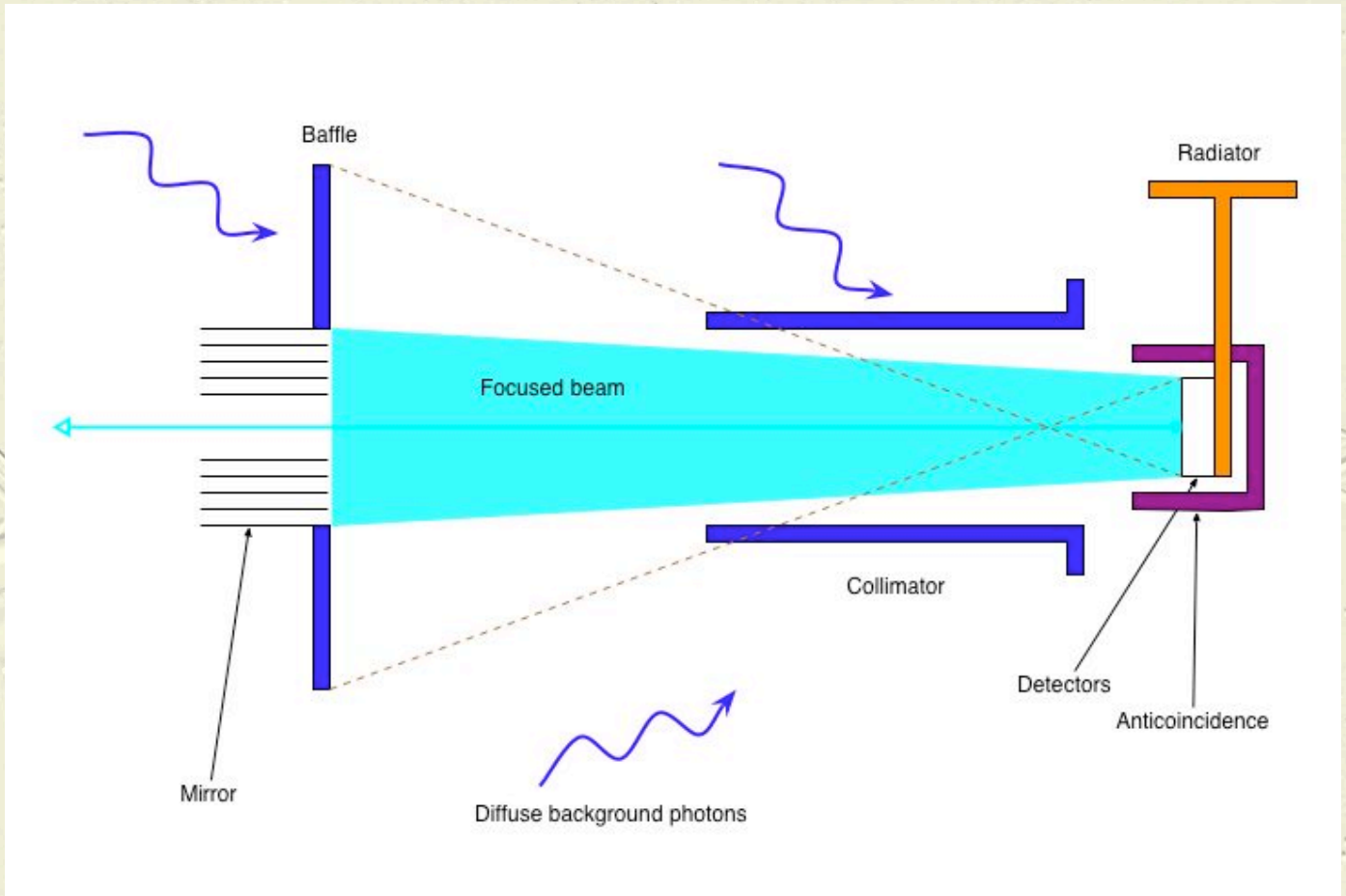
- ASICs development (IDeF-X Vx.x)



- Hybridization

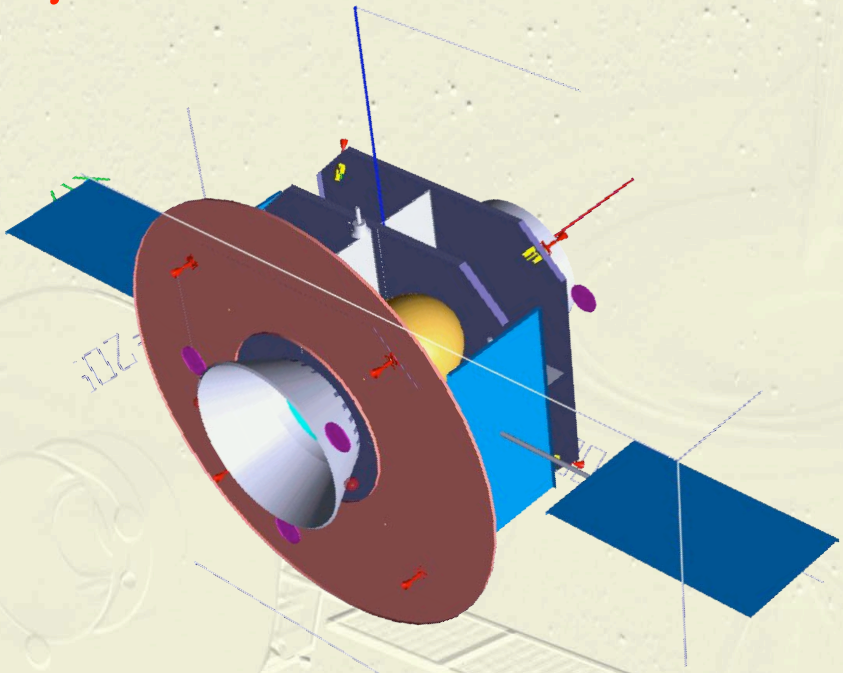


Diffuse X-ray Background baffling issue



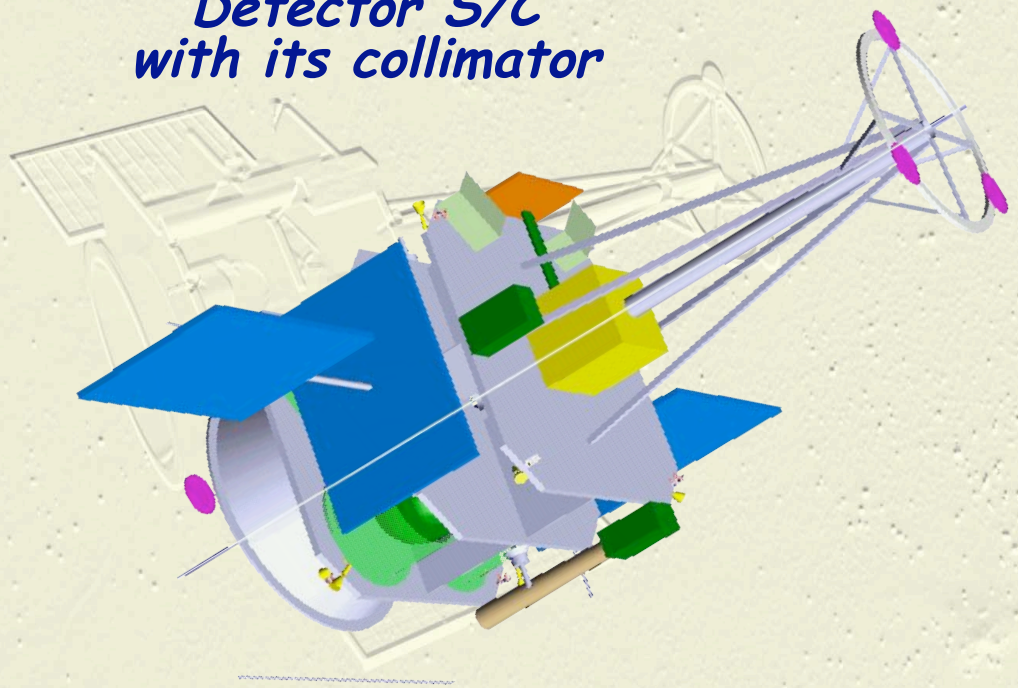
Detector and Mirror Spacecrafts

One major point achieved in phase 0 :
feasability of the background reduction

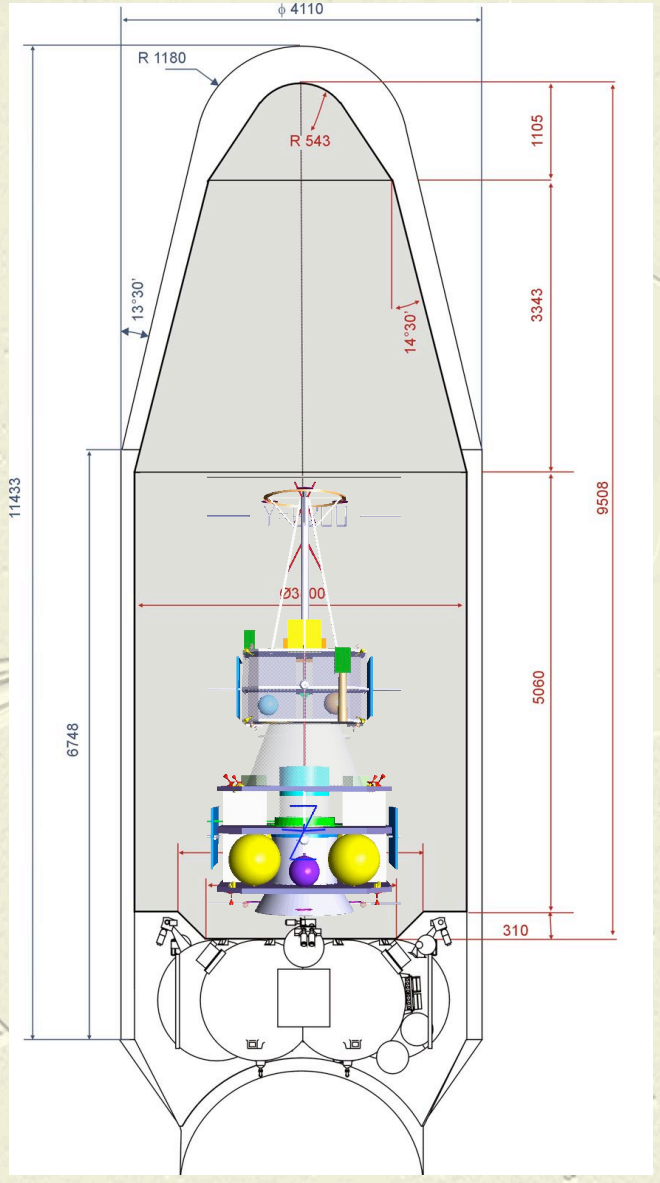


Mirror S/C
with its sky shield

Detector S/C
with its collimator



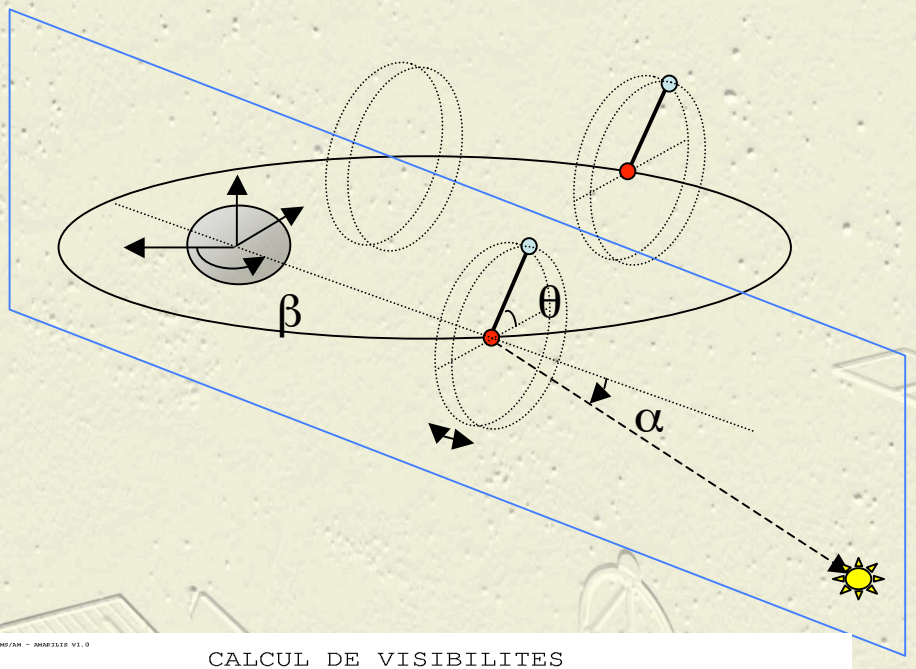
Packing for launch



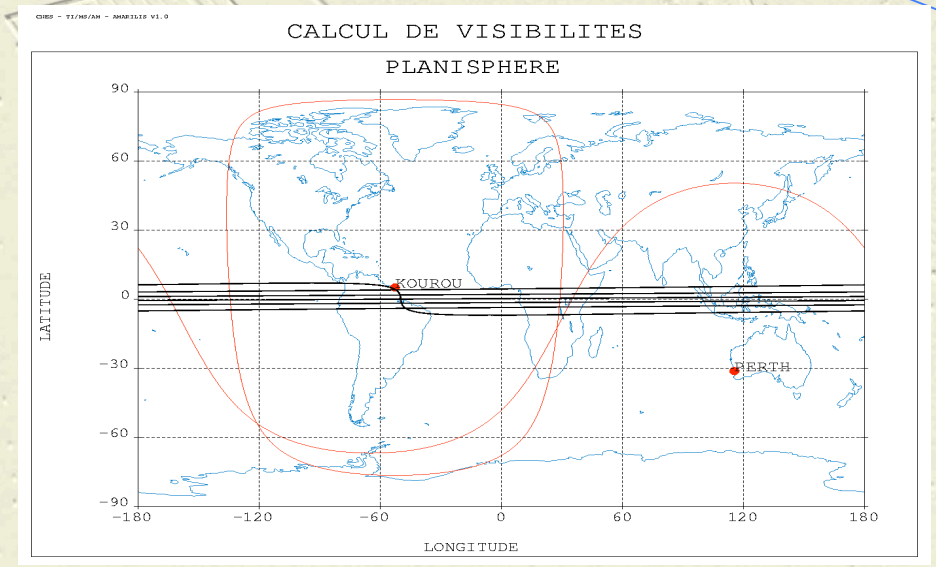
Single launch

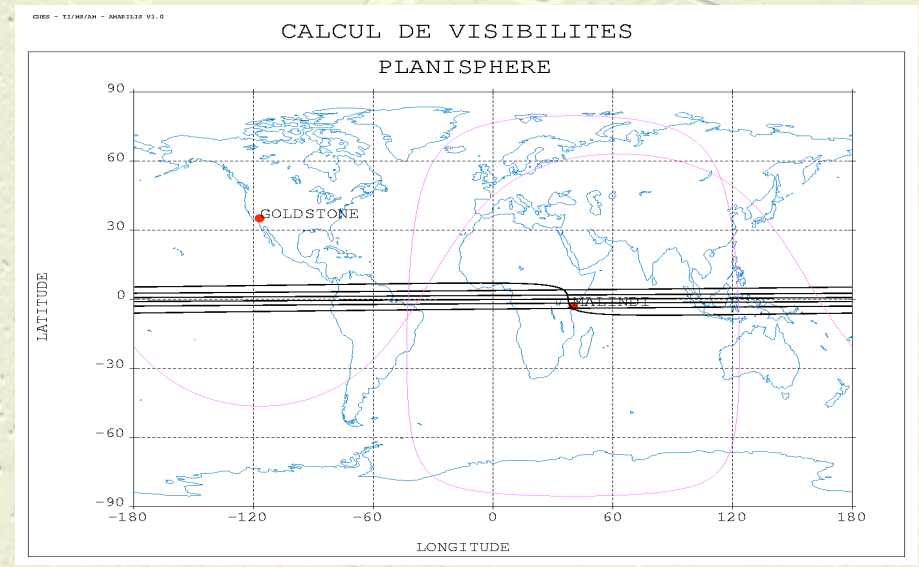
Soyuz-Fregat from Kourou

Mission operations - orbit



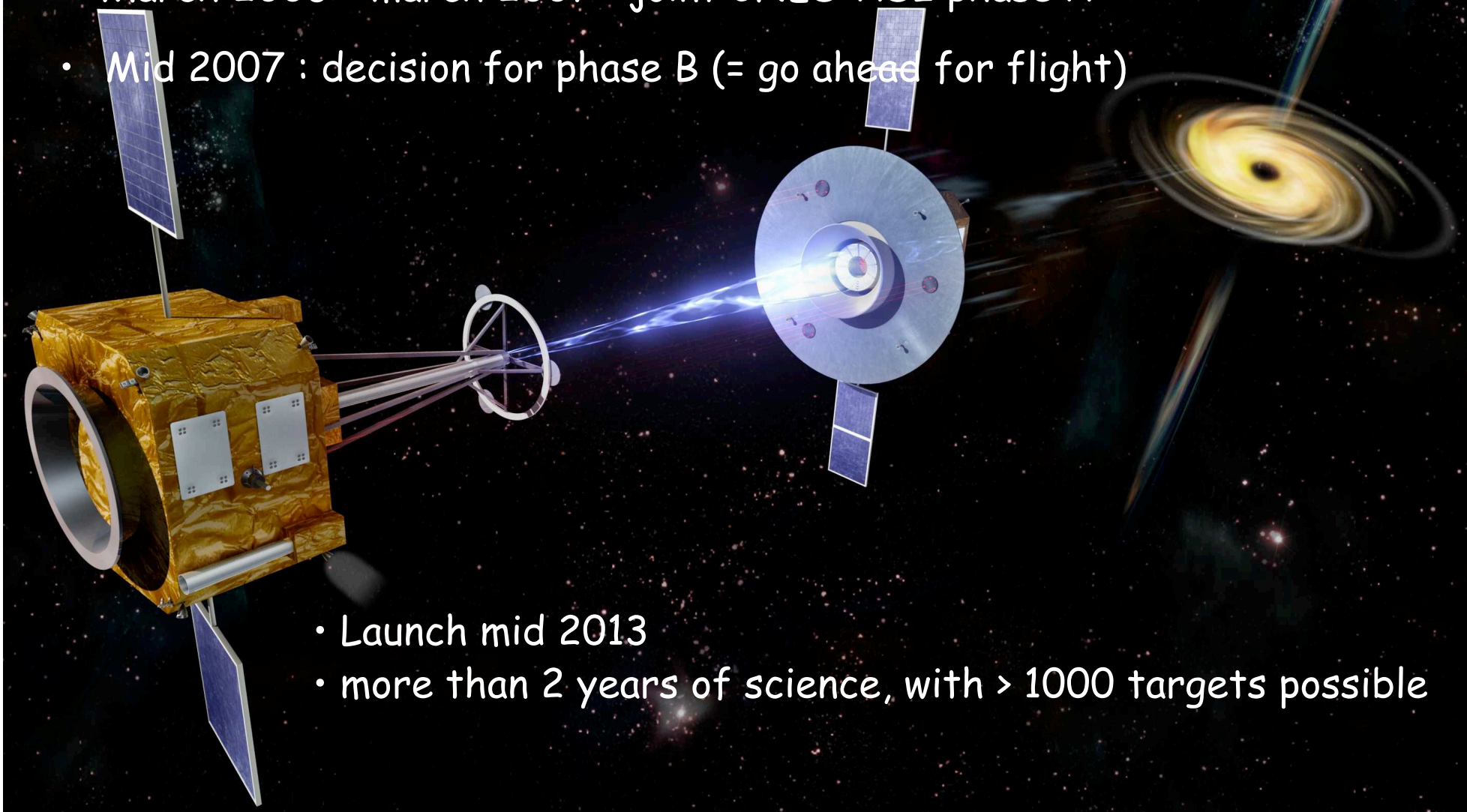
- High elliptical orbit :
  7 days period, and at launch :
  perigee : 44,000 km
  apogee : 253,000 km
  inclination : 5 degrees
- Pointing perpendicular ± 20 deg to Sun - S/C line
- 2 antennas on ground





Project time schedule

- Oct. 21, 2005 : selection for phase A by CNES Science Program Committee (end of process from call for ideas issued in Dec 2003)
- March 2006 - march 2007 : joint CNES-ASI phase A
- Mid 2007 : decision for phase B (= go ahead for flight)



- Launch mid 2013
- more than 2 years of science, with > 1000 targets possible